Ecosystem Assessment and Restoration

Research to support ecosystem assessment and restoration is one of EPA's highest priorities. At ORD, the objective of ecosystem research is to provide information that truly reflects the scale of the problem, need for action, causes of harm, and success of mitigation and restoration efforts; computer models that integrate the impact of multiple factors causing ecological degradation and are appropriate to the scale of the problem; risk assessment techniques that accurately quantify risks to ecosystems; and restoration and protection strategies that are cost-effective. This chapter describes recent ORD accomplishments in ecosystem research.

MONITORING COASTAL CONDITION

The National Coastal Condition Report was produced through EPA's Environmental Monitoring and Assessment Program (EMAP). Released in 2001, the report exemplifies cooperation between EPA and State, local, tribal, and federal natural resource trustees. The National Coastal Condition Report is a major demonstration of the type of information generated by EMAP.

Most of the data used to develop the Report were collected in estuaries—areas where rivers and streams flow into the ocean. Due to the influx of nutrients from the land and the mixing action of tides and currents, estuaries and their associated wetlands are among the world's most diverse and productive ecosystems. Because estuaries are important commercially and environmentally, programs monitoring estuarine conditions have been in place since at least 1990.

Seven primary indicators of aquatic ecosystem health were used for the National Coastal Condition Report: water clarity, dissolved oxygen, coastal wetland loss, eutrophic condition (presence of excess nutrients), sediment contamination, benthic condition (status of bottom-dwelling ecological

Questions that Drive EPA's Ecosystem Research

- What is the current ecosystem condition, how has ecosystem condition changed over time, and what factors (stressors) appear to have been responsible for harm or deterioration?
- How do biological, chemical, and physical processes affect the condition of ecosystems?
- How can we most accurately diagnosis problems facing ecosystems and forecast future effects of stresses to ecosystems?
- What relative risks do stressors (alone and in combination) pose to ecosystems now and in the future?
- How can we most effectively reduce risks to protect ecosystems and restore them once they have become degraded?

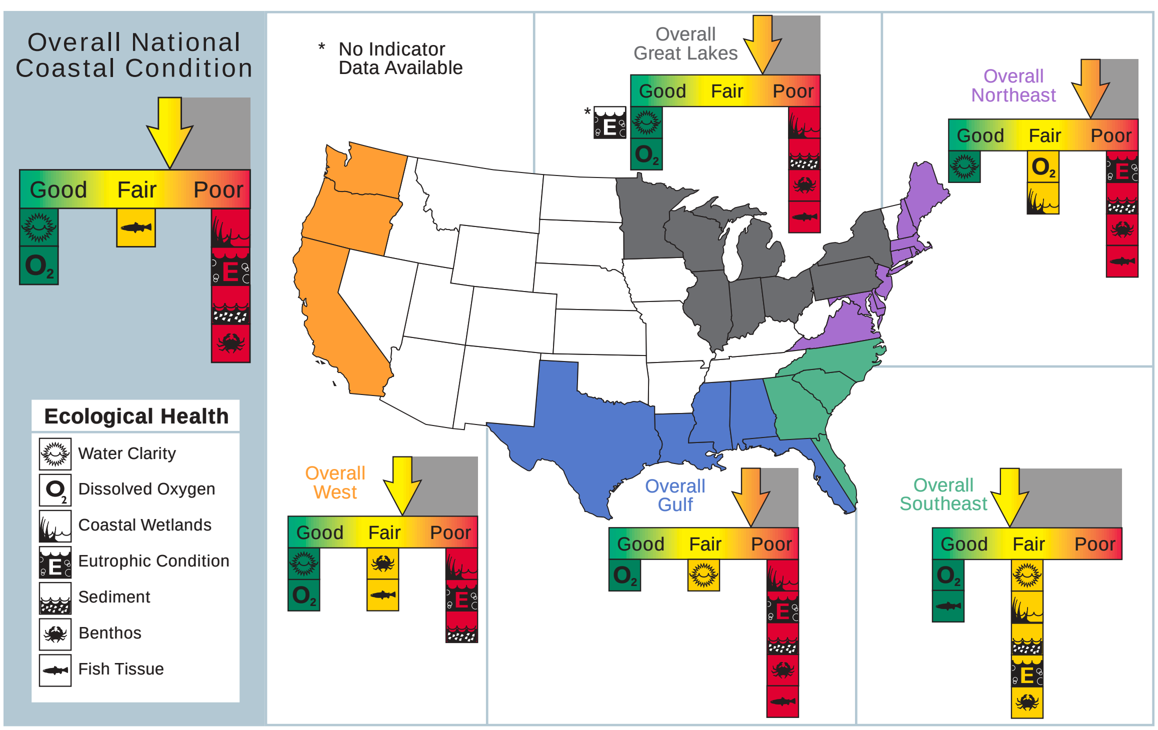
Environmental monitoring, which enables scientists to observe trends in changing conditions, is the cornerstone of ecosystem assessment.

communities), and fish tissue contamination. In each coastal area studied, the condition of each indicator was rated as good (5), fair (3), or poor (1). Available information enabled full assessments of the northeastern, southeastern, and Gulf of Mexico estuaries. Partial assessments were made of West Coast estuaries and the Great Lakes. The national score was derived as the average of regional scores, weighted by the amount of estuarine area in each coastal area studied.

The overall condition of the Nation's estuaries was fair to poor. Nearly half (44%) of the estuaries were impaired in their ability to support healthy aquatic life and/or full human use, such as fishing and swimming. The lowest-scoring ecosystem indicators were coastal wetland loss, eutrophic condition, and benthic condition, while the highest-scoring indicators were water clarity and dissolved oxygen concentration. This report provides an important baseline for evaluating the progress of coastal preservation and restoration projects.

PREDICTING NUTRIENT AND SEDIMENT LOADINGS

Two of the most important stressors to aquatic ecosystems are excessive nutrients and sediment, which upset the balance of microbial, plant, and animal life. Scientists from ORD and other federal agencies are working together to



develop computer models that predict nutrient and sediment loadings to streams in the Mid-Atlantic area of the country. These models should be broadly applicable across the Mid-Atlantic area because they are based on data from a large number of sites (148) representing several settings with diverse biological and physical features.


Photo from space of the sediment-laden James River entering Chesapeake Bay near Norfolk, VA.

Photo courtesy of Earth Sciences and Image Analysis Laboratory, NASA-Johnson Space Center

The researchers developed landscape metrics (see sidebar) and related them to in-stream measurements of nitrogen, phosphorus, and sediment. Nitrogen, phosphorus, and sediment levels in the streams of the Chesapeake Bay Basin, which contains 150,000 stream miles in the Mid-Atlantic area, were highly correlated with the amount of agriculture, forest adjacent to streams, nitrate from precipitation, and roads in the watershed. Because of the strong correlation between certain landscape metrics and nutrient and sediment loads found in this study, it will be possible to estimate loading to streams across the Mid-Atlantic area using extensive landscape data collated by EPA. Also, it should be possible to evaluate the likelihood of exceeding nutrient and sediment thresholds for many streams across the region.

Landscape metrics are measurable features, such as percentage of an area covered by forest. For this study, landscape metrics were developed from a database for the Mid-Atlantic area that included data on land cover, regional topography, soil type, stream networks, road networks, and human population density. The following landscape metrics are examples of those used in the research.

Riparian agriculture: percent of watershed with agricultural land adjacent to stream edge.

Agricultural land cover: percent of watershed with pasture/crops.

Riparian forest: percent of watershed with forest adjacent to stream edge.

Atmospheric nitrate deposition: estimated average annual deposition of nitrate in precipitation.

Road density: average length of road per area of watershed.

Roads near streams: percent of total stream length having roads within 30 meters of the stream bank.

Slope gradient: average percent slope gradient for watershed.

Potential soil loss: percent of watershed with the potential for soil losses greater than 2000 pounds per acre per year.

Working under ORD's STAR grant program, a scientist at the Reef Indicators Lab of the University of South Florida has developed guidelines for using foraminifera, tiny marine organisms, as ecological indicators of vitality for coral reefs. The organisms with uniform pinwheel stripes are healthy; the ones with irregular white blotches are bleached, evidence of damage. Foraminifera range in size from 0.1 to 3 mm in diameter.

STUDYING MERCURY CYCLING

Mercury is a naturally occurring element that cycles between the atmosphere, land, and water. Emissions from human activities, such as burning coal for electricity and incineration of municipal waste, are the largest contributors of biologically available mercury to the environment.

ORD scientists developed an instrument to detect different forms of mercury in the atmosphere. Using an aircraft equipped with this apparatus, the researchers learned that elemental mercury can be transformed to reactive gaseous mercury in the middle and upper layers of the troposphere (the atmospheric layer closest to the ground). Reactive gaseous mercury is more readily removed from the atmosphere and deposited on land and water than elemental mercury. Prior to this research, elemental mercury—the predominant form in the atmosphere—was believed to be largely inert and hence typically transported long distances. Apparently, mercury from both nearby and distant sources contributes to both local and regional deposition. Since the initial flights, which occurred off the coast of Florida and over the Gulf of Mexico, ORD scientists have corroborated the original findings using similar instruments deployed at a land-based, high-altitude research station in Hawaii.

The specific mechanisms by which elemental mercury is transformed to reactive gaseous mercury are yet to be determined. However, ORD scientists studying atmospheric mercury in the Arctic and Antarctic found evidence that bromine-containing and chlorine-containing compounds can be formed in the atmosphere and, in turn, react with elemental mercury to produce reactive gaseous mercury.

Mercury

EPA's Mercury Study Report to Congress identified mercury as a human health and environmental problem requiring additional scientific and technical research. Adverse effects on mammals, fish, and birds include behavioral abnormalities, impaired growth and development, reduced reproductive success, and death. Consumption of contaminated fish is the major exposure pathway for humans and wildlife.

These findings imply that atmospheric mercury is much more dynamic than we had thought and that controlling mercury emissions can result in meaningful decreases in the amount of mercury being deposited on land and water.

Two teams of scientists working under ORD's Science to Achieve Results (STAR) grant program are studying mercury cycling in natural waters. One team is using a combination of field and laboratory experiments to investigate the major chemical and biological mechanisms responsible for the transformations between various forms of mercury. During the first year of research, the scientists discovered that the oxidation of elemental mercury in surface waters in the presence of sunlight, a process that was thought to be insignificant, is a very important aspect of mercury cycling and transformation. Therefore, daily and seasonal variations in sunlight should be considered when calculating mercury budgets in aquatic systems and when developing sampling protocols.

The second team of STAR grant recipients is conducting comprehensive field and laboratory studies of mercury cycling in the coastal and estuarine waters of Long Island Sound and its river-seawater mixing zones. These researchers are investigating the chemical and biological reactions and processes controlling mercury cycling and bioavailability in waters and sediments. The scientists designed an Automated aqueous Gaseous Elemental Mercury sampling and analysis System (AGEMS) for ship-board use that allows direct analysis of elemental mercury in surface waters. Sampling excursions have identified spatial and seasonal patterns in the distribution of elemental mercury in Long Island Sound.

Sample water is delivered to the glass bubbler portion of the AGEMS system shown here. A measured volume of sample water is purged with nitrogen gas and the elemental mercury from the water sample is delivered to the analytical portion of the system.

LOOKING TO THE FUTURE

Upcoming accomplishments include

- *a report assessing the condition, vulnerability, and restoration potential of streams and their watersheds in the Mid-Atlantic area,*
- *a report on trends in acid deposition and the acidity of lakes and streams, to assess progress toward reducing the impacts of acid rain, and*
- *development and evaluation of new, cost-effective indicators to evaluate the ecological condition of aquatic and terrestrial environments.*